GULL LAKE

Alberta
ENVIRONMENT

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Lakes attract people. And people want to know why "their" lake is the way it is — why is it so green in July? Is the water quality really deteriorating? How do our activities affect the lake?

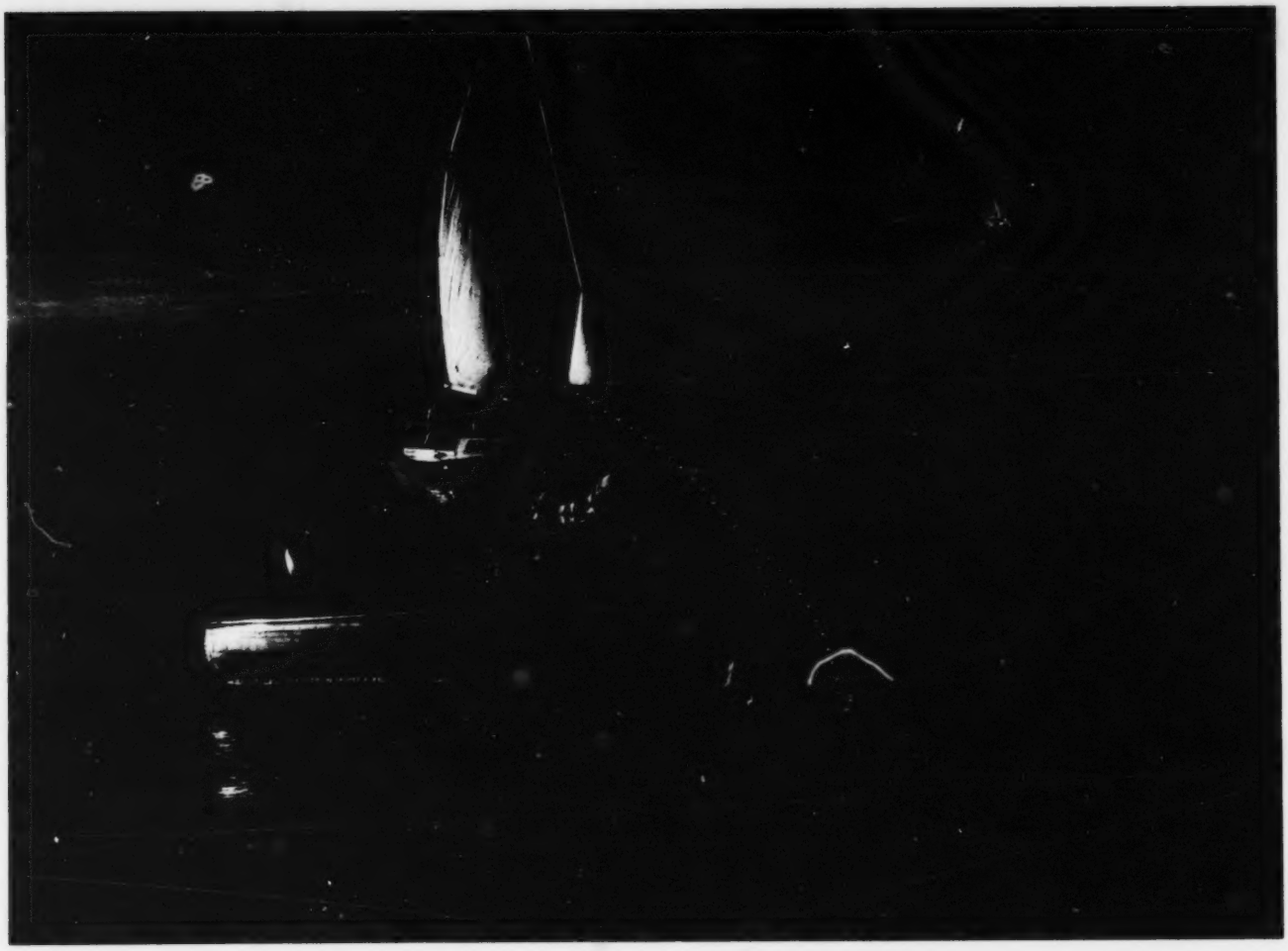
This brochure, one of a series on Alberta's lakes, attempts to answer these questions by presenting findings of water quality studies conducted by the Environmental Assessment Division of Alberta Environment.

As you read through the brochure, you may find that you have questions about the concepts and illustrations. At the end is a section called **Explanation of Lake Characteristics**. Refer to this for further interpretation.

Brochures are available for the following lakes:

Sandy Lake	Pine Lake	Lac la Biche
Lac la Nonne	Garner Lake	Nakamun Lake
Wizard Lake	Skeleton Lake	Lac Ste. Anne
Pigeon Lake	Jackfish Lake	Baptiste Lake
Lake Isle	Island Lake	Gull Lake
Moose Lake		

July 1989



Gull Lake is a large, shallow lake located 14 km west of Lacombe on Highway 12. Its fine beaches and clear water attract many visitors throughout the summer. The north end of the lake is an excellent place to view waterfowl.

The region around the lake was settled by about 1900. Most of the forest was being cleared at that time, and a sawmill was built at Birch Bay on the west shore. A 26-metre-long steamboat carried both logs and passengers around the lake.[1] The water level was much higher fifty years ago, and now many cottages are quite far from the edge of the water and beaches are wide.

In 1932, Aspen Beach Provincial Park on the south end of Gull Lake became the first provincial park in Alberta. Most development and recreational activity occurs in this region of the lake, and the summer village of Gull Lake is also located here. Other developments around Gull Lake include the summer village of Parkland Beach, several subdivisions, campgrounds, day use areas, and institutional camps.

Fishing

Fishing is a popular activity on Gull Lake. Northern pike (jackfish) and walleye are the most sought-after fish. The weedy northern end is prime habitat for northern pike. There has been an ongoing program to improve the walleye population in this lake. Walleye were stocked as fry in 1987, 1988 and 1989. Their success will be evaluated when these populations reach catchable size. Other fish in Gull Lake include lake whitefish, which were first stocked in 1975, burbot, white suckers, spottail shiners and brook stickleback. Yellow perch have also been stocked in Gull Lake, but may not have survived.[2]

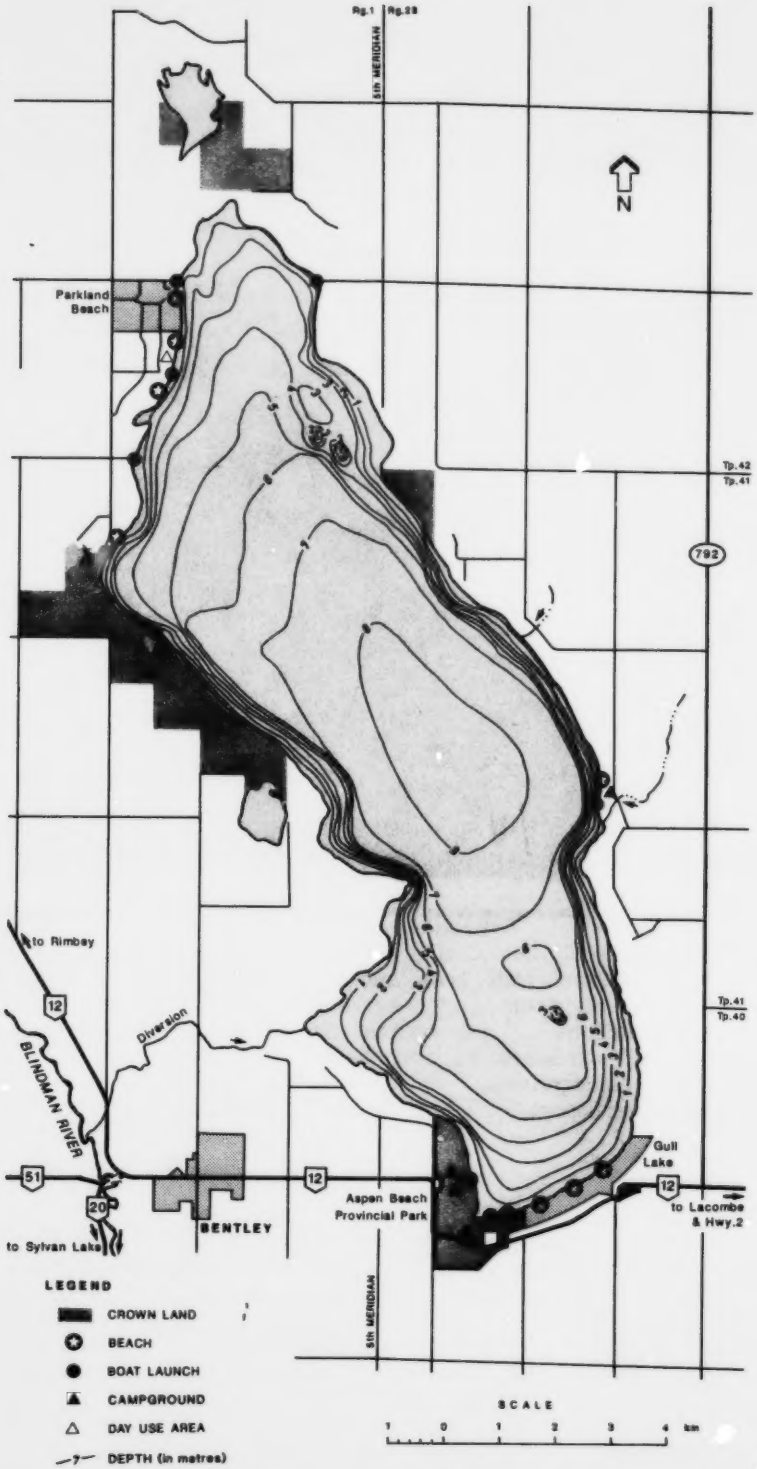
Physical Characteristics

As can be seen on the Depth Contour map, Gull Lake has one large, shallow basin, which lies oriented in the direction of the prevailing winds. When it is windy, the water can become very rough. The sandy beaches on the south end probably result from the wind and wave action.

The water level in Gull Lake has been declining since before 1924 (see the Historical Water Level graph). This is obvious when one sees how far the older cottages are from the present shoreline. Although the reason for the decline is

1. Coulton, R.L. 1975. A guide to the historic sites of the Gull Lake region of Alberta. R.L. Coulton, Bentley, Alberta.
2. Alberta Forestry, Lands and Wildlife, Fish and Wildlife Division.

Depth Contours of Gull Lake



unknown, it is probably because more water is evaporating from the lake than is entering it from precipitation and runoff. There may have been changes in the flow of groundwater to the lake as well.

Water flows into Gull Lake through several small, intermittent streams. The outlet channel on the southwest corner has not flowed to the Blindman River since the lake level dropped below the outlet level many years ago. In the early 1900s there was a dam on the outlet creek, and Gull Lake was used for a short time as a hydroelectric reservoir.

The declining level of Gull Lake has caused much concern to land owners along the shore. To stabilize the lake, Alberta Environment constructed a diversion from the Blindman River through the old outlet channel into the southwest corner of the lake. Pumping, which began in 1977, occurs only when the lake is below a designated "target elevation" of 899.08 m and when there is enough water flowing in the Blindman River. This target elevation was reached during most of the period between 1982 and 1986, so there was very little diversion. The maximum quantity of water pumped during a full pumping season is about 11 x 10^6 m^3.[3]

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

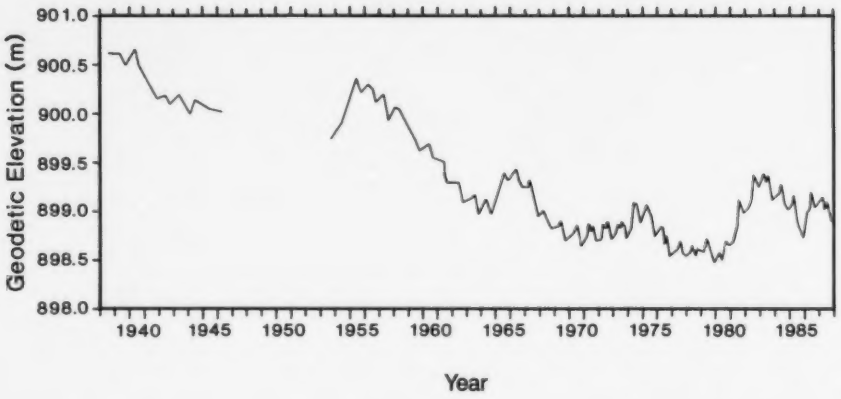
LAKE AREA[a]	km^2	80.6	
DRAINAGE AREA (excluding lake)	km^2	197	
DRAINAGE AREA/ LAKE AREA		2.4	
VOLUME[a]	m^3	437	x 10^6
MAXIMUM DEPTH[a]	m	8	
MEAN DEPTH[a]	m	5.4	
SHORELINE LENGTH	km	58	
TOTAL INFLOW[b]	m^3/yr	51.5	x 10^6
EVAPORATION	m^3/yr	51.6	x 10^6
RESIDENCE TIME[b]	years	>100	

[a] on date of sounding, August 1961
[b] excludes Blindman River diversion and groundwater

Reference: Alberta Environment, Technical Services Division

3. Alberta Environment, Development and Operations Division.

Historical Water Level of Gull Lake



Nutrient Sources

Algae and other plants in a lake depend on nutrients such as phosphorus and nitrogen for their growth. The most important nutrient from a water quality point of view is phosphorus, because the amount available in lakes is often so low that it controls the amount of algae the lake will produce.

Phosphorus enters Gull Lake in runoff when it rains and as snow melts in spring, directly onto the lake as precipitation and dust, and possibly in sewage effluent from lakeshore cottages. There is also phosphorus in diversion water pumped from the Blindman River.

The Theoretical External Phosphorus Supply table shows the amount of total phosphorus that is estimated to enter Gull Lake from these "external" sources each year. Cleared or agricultural land contributes the largest amount of phosphorus because most of the watershed surrounding the lake has been cleared (see the Watershed map). In addition, cleared land is estimated to contribute two to five times more phosphorus than a similar area of bush or forested land. The amount of phosphorus that might be derived from leaking sewage systems is likely very low, but has not been measured on Gull Lake; the value reported in the table was estimated using data from studies on other lakes. The Blindman River diversion would contribute about 10% of the total yearly phosphorus input during a full pumping season.

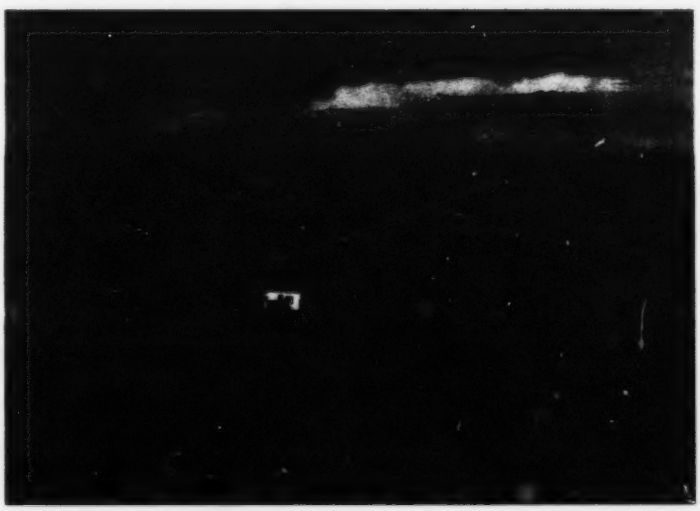
To compare the total annual phosphorus supply among lakes, the total is divided by the lake area. The AREAL LOADING value of 0.07 g/m² for Gull Lake is low; for example, the areal load for Baptiste Lake is 0.35 g/m² and for Lake Isle is 0.33 g/m². The low value for Gull Lake suggests it should have good water quality.

In addition to these external sources, there is a large source of phosphorus in the lake bottom sediments or mud. Under certain conditions, usually in mid-summer, phosphorus may move out of the sediments and "fertilize" the water above them. This internal source has not been quantified on Gull Lake, but it could be very significant.

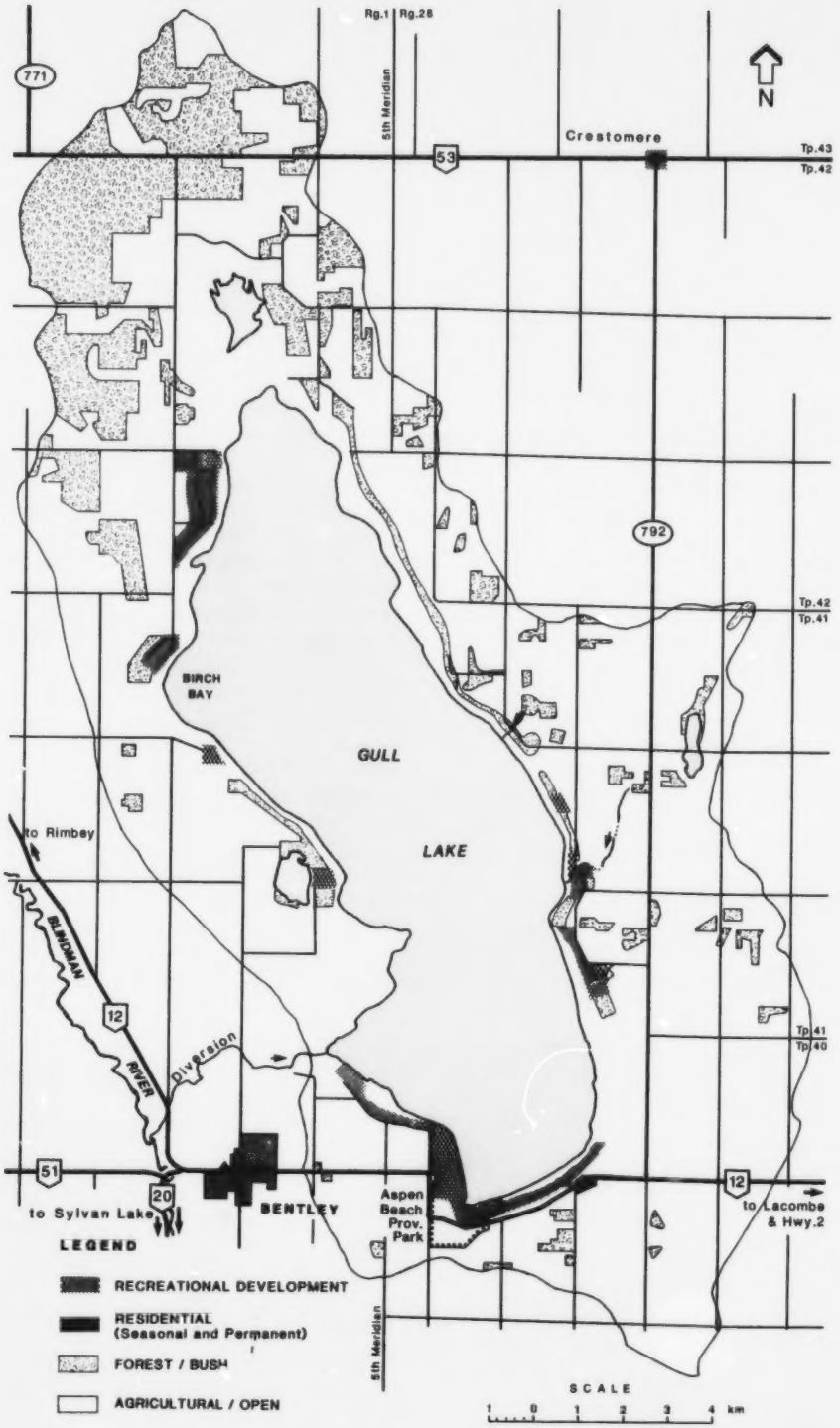
THEORETICAL EXTERNAL PHOSPHORUS SUPPLY

	kg/year	percentage
SURFACE RUNOFF:		
Forested/Bush	434	7
Cleared/Agricultural	3032	51
Urban/Cottage	102	2
PRECIPITATION, DUSTFALL	1760	29
BLINDMAN RIVER DIVERSION*	615	10
SEWAGE FROM COTTAGES AND CAMPS	35	<1
TOTAL	5978	100
AREAL LOADING, g/m² of Lake Surface	0.07	

* full pumping season



Watershed Map of Gull Lake

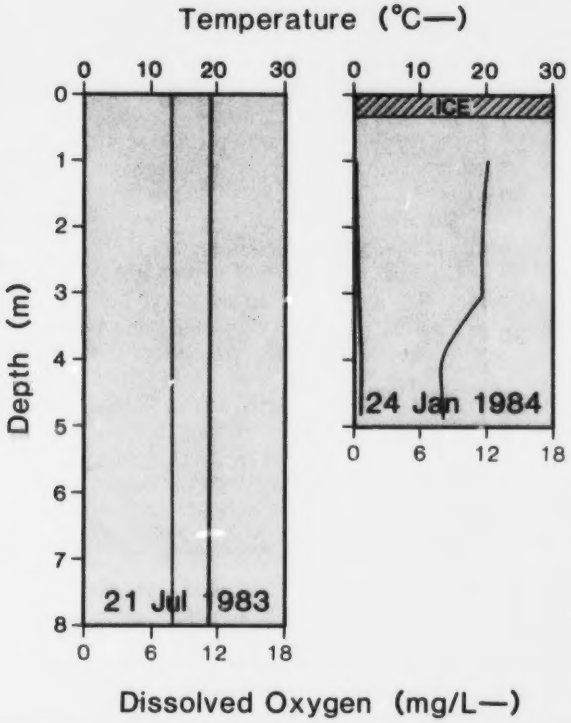


Temperature and Dissolved Oxygen

Because Gull Lake is shallow and exposed to wind, the water mixes from the lake surface to the bottom during most of the spring, summer and fall. The Temperature and Dissolved Oxygen graph for 21 July 1983 shows temperature and oxygen patterns for a typical summer day in Gull Lake. The temperature of the water was uniform from the surface to the bottom and the oxygen level was very high.

In winter, when ice prevents the wind from mixing Gull Lake, as on 24

Temperature (°C) and Dissolved Oxygen (mg/L) in Gull Lake



January 1984, the temperature at the bottom of the lake is slightly higher than at the surface because the warmer water is more dense. Oxygen may decline to levels that are quite low near the lake bottom in winter, but there is probably always sufficient oxygen near the surface to support fish. There have been no winterkills recorded for Gull Lake.

Chemistry

The water of Gull Lake is slightly salty or saline. Higher salinity is common in lakes that have no outflow, because the salts become concentrated in the lake as the water evaporates. The major ions in the water are bicarbonate (HCO_3), sodium (Na) and magnesium (Mg). During years when water is diverted from the Blindman River into Gull Lake, the salinity declines slightly as the lake water is diluted. The pH of Gull Lake is fairly high or alkaline but its chemistry remains suitable for fish and other aquatic life.

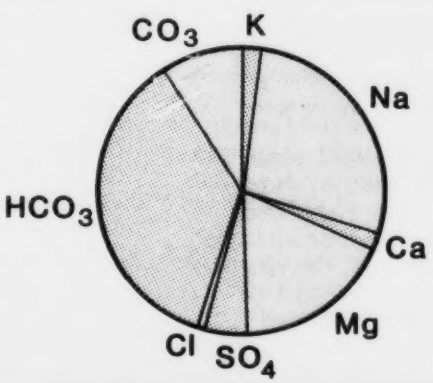
CHEMISTRY average, May - September 1983-1985

CONDUCTIVITY	µS/cm*	1144
pH (RANGE)		9.0 - 10.1
ALKALINITY	mg/L**	623
TOTAL DISSOLVED SOLIDS	mg/L	713
NUMBER OF SAMPLES		8

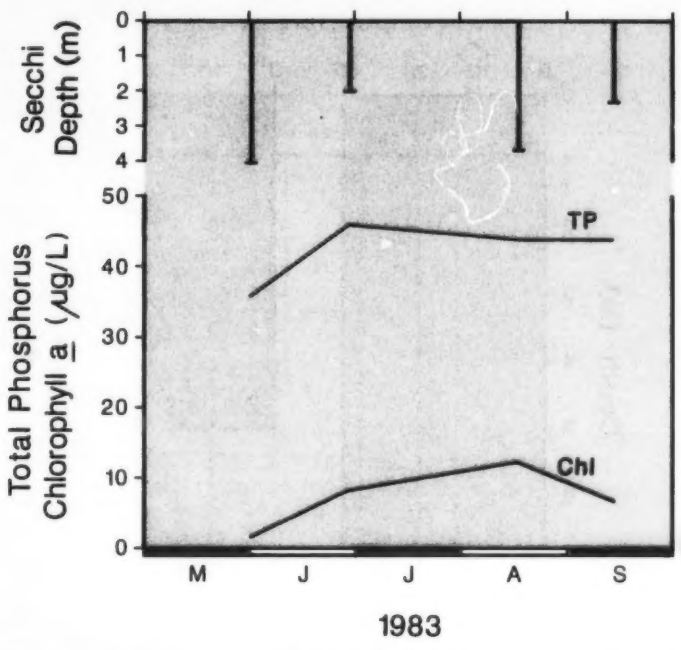
* microsiemens per cm - a measure of the resistance of water and its dissolved salts to electrical flow.

** milligrams per litre = parts per million.

IONIC DIAGRAM - Relative Proportions of Ions in Gull Lake 1983 - 1984



Trophic Status of Gull Lake



Trophic Status

Although the external supply of phosphorus to Gull Lake is estimated to be comparatively low, the concentration of phosphorus in the water is fairly high, possibly because there are large quantities of this nutrient in the bottom mud of the lake. Based on the concentrations in the water, one might expect Gull Lake to be very green with algae. But chlorophyll levels are low and the lake is classified as MESOTROPHIC. The water is often clear, although sometimes tinged with green. It is thought that the saltiness of the water suppresses algal growth somewhat. Aquatic vegetation is luxuriant in protected bays and in the north end. At the south end, the sandy bottom and wave action tend to inhibit weed growth.

So far, the diversion water has had no adverse effect on water quality in Gull Lake, even though nutrient levels in the river are higher than those in the lake. The volume of river water pumped during a full pumping season is very small compared to the volume in the lake, and it appears that pumping won't take place every year. Thus, the impact on the lake should remain minimal.[4]

The Trophic Status graph shows how levels of phosphorus and chlorophyll a changed from May to September in 1983. Phosphorus and chlorophyll usually increase in late summer as phosphorus moves from the bottom sediment into the water and algal growth is stimulated. This pattern is often seen in shallow lakes like Gull Lake. The types of algae that are most common in Gull Lake are typical of mesotrophic lakes. Blue-green algae grow in the lake from June to August but they rarely reach nuisance levels. In most lakes the transparency of the water (Secchi depth) is highest when there is little algae in the water. In Gull Lake the clarity of the water is related also to the amount of sediment stirred into the water from the shallow bottom on windy days.

TROPHIC CHARACTERISTICS average values May - September

		1983	1984
PHOSPHORUS	µg/L*	43	41
NITROGEN	µg/L	1540	**
CHLOROPHYLL	µg/L	7	6
SECCHI TRANSPARENCY	m	2.9	3.1

* micrograms per litre - one millionth of a gram in a litre of water = parts per billion.
** no data available.

4. Mitchell, P.A. 1981. Gull Lake - Effects of Diversion on Water Quality. Alberta Environment, Pollution Control Division, Water Quality Control Branch, Edmonton.

Explanation of Lake Characteristics

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Drainage Area or the watershed of a lake is the land surface from which a lake receives its water. As rain water or snowmelt gathers in streams, it picks up soil particles, nutrients and other materials and carries them to the lake.

A study of more than 30 Alberta lakes shows that when drainage areas are large compared to lake areas, (i.e. when the **Drainage Area/Lake Area** ratio is large), lakes have more algae (are more eutrophic) (see TROPHIC CHARACTERISTICS).

Mean Depth is the volume of the lake divided by the surface area. Shallow lakes are often more eutrophic than deeper lakes of a similar surface area.

Inflow is the total volume of water entering the lake in a year. It is related to **Residence Time**, which is the time it would take the inflow to completely fill the empty lake basin.

The **Geodetic Elevation** on the water level graph indicates the level or elevation of the lake above mean sea level.

TEMPERATURE

Alberta lakes show two basic annual patterns of temperature distribution through the water.

Deep lakes, or those protected from strong winds, form layers with the coldest water near the bottom in summer. Because this colder water is denser, it resists mixing into the warmer, lighter, upper layer.

For much of the summer, the bottom portion of water is isolated from the top portion. In spring and fall, these lakes usually mix from top to bottom by wind action as the water becomes uniform in temperature and density. In winter, under ice, the warmest water (about 4°C) is on the bottom, because water is most dense at this temperature.

Shallow lakes mix throughout the summer or layer only temporarily. In winter, the temperature pattern of these lakes is similar to that of deep lakes.

DISSOLVED OXYGEN

Oxygen is essential to the life in lakes. Oxygen from the air dissolves readily in water, especially on windy days when waves break up the lake surface. The photosynthesis of small aquatic plants also supplies a large amount of oxygen to the lake water.

Oxygen is consumed by respiration of animals and plants, and by the decomposition of dead organisms by bacteria. A great deal can be learned about the "health" of a lake by studying its patterns and quantity of oxygen.

Lakes that are unproductive (oligotrophic) will have sufficient oxygen throughout the year at all depths. But as a lake becomes more eutrophic, and increasing quantities of plants and animals respire and decay, the balance shifts towards consumption — especially near the lake bottom where dead organisms accumulate.

In deep productive lakes (see TEMPERATURE), the oxygen in the isolated bottom layer may deplete rapidly, forcing fish to move into the upper layer (fish are stressed when oxygen falls below about 3 mg/L). Fish kills occur when decomposing or respiring algal populations use up the oxygen. In summer, this usually happens when an algal bloom "collapses" or dies suddenly.

SALINITY AND TOTAL DISSOLVED SOLIDS

Lake water contains a multitude of dissolved substances. These can be seen by allowing a dish of lake water to evaporate. If the water is filtered to remove living organisms and other particles, and then allowed to evaporate, the residue is called **Total Dissolved Solids**.

The ions* that make up most of this residue can be measured individually. The **Ionic Diagram** presents all of the major ions in a lake in proportion to each other. The salinity or saltiness of the water is indicated by its **conductivity**. Water that is low in conductivity (salinity) conducts electricity poorly.

Salinity is controlled by the types of rock or soil in the watershed and by the amount of evaporation relative to precipitation. Lakes of high salinity, such as many of those found in southeastern Alberta, have fewer species of plants and animals than freshwater lakes; many are too saline to support fish.

* Ions: Chemical form in water of constituents such as sodium and carbonate.

pH AND ALKALINITY

The **pH** of lake water refers to its concentration of hydrogen ions on a scale that runs from 0 (extremely acidic) to 14 (extremely alkaline). A pH of 7 is neutral - neither acidic nor alkaline.

Most Alberta lakes fall between pH 6 to 9, with the majority on the alkaline side. **Alkalinity** refers to the capacity of water to neutralize an acid, and is a measure of the alkaline materials present in the water.

Alberta lakes that were formed in sedimentary bedrock have a large capacity to neutralize acids entering them, such as from acid rain.

THEORETICAL PHOSPHORUS SUPPLY

Lake scientists know that for most lakes, the amount of algae in the water is related directly to the amount of phosphorus. This is because phosphorus is usually in shortest supply relative to all the nutrients that lake plants need. When it runs out, the algal population can no longer increase. A larger phosphorus supply usually results in more algae.

Based on studies from all over North America, the quantity of phosphorus contributed by a hectare of forest during runoff is remarkably similar no matter where the lake is located. Similarly, agricultural or cleared land overlying sedimentary bedrock contributes fairly similar quantities of phosphorus per hectare in most lake watersheds. This was confirmed for Alberta by measuring quantities of phosphorus supplied by various land uses in several lake watersheds.

In all studies, the phosphorus supply from cleared or agricultural lake was greater than that from forest, averaging 2 to 5 times more.

The **Theoretical Phosphorus Supply** is estimated by multiplying phosphorus supply factors for each type of land use by the area of that land use, and then summing the products.

Similar factors are used for the supply from precipitation. The supply from sewage is estimated based on a percentage of the total amount that could be generated by cottages and camps on the particular lake.

It might be expected that a large phosphorus supply would produce a eutrophic lake. But the size of the lake is also important. If the total phosphorus supply is divided by the surface area of the lake, the resulting **Areal Loading** figure can be compared with other lakes, and can be used as an indication of trophic status.

TROPHIC CHARACTERISTICS

The word "trophic" literally means nourishment.

Mountain lakes usually are "poorly nourished" or **oligotrophic**. Levels of nutrients such as phosphorus and nitrogen are low, plant life is sparse, and the water is clear. Fish production is low.

On the other end of the scale are well-nourished or fertile lakes called **eutrophic**. In these lakes, aquatic plants, including tiny suspended algae, flourish because the water contains abundant nutrients.

Mesotrophic lakes, those intermediate in fertility, often combine the best features of the other two types.

In some lakes, the nutrient supply is so high that plant growth inhibits certain recreational uses of the lake. Lake users may consider such a lake to have poor water quality. One of the purposes in studying lakes is to determine whether fertility is increasing.

There are several ways to measure a lake's fertility or **Trophic Status**.

Phosphorus and **nitrogen** can be measured directly. Phosphorus in lakes of the Boreal Forest/Parkland areas of Alberta ranges between 10 and 200 micrograms per litre* (μg/L) (oligotrophic to highly eutrophic), and nitrogen ranges between 500 and 3500 μg/L.

Transparency of the water declines as a lake becomes more fertile. It is measured with a black and white plate called a **Secchi Disk**, which is lowered through the water on a line marked at metre intervals. The depth at which it can no longer be seen is the **Secchi Transparency**.

The quantity of algae in the water can be determined by measuring its content of **Chlorophyll a**, the green photosynthetic pigment.

* equivalent to parts per billion

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